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TITLE:

Semi-Permanent Reference Electrode

INVENTORS

Darrell S. Dunn
Christopher Sean Brossia

Applicant claims priority under 35 U.S.C. §119 of U.S. Provisional Application Serial No. 60/466,128 filed April 28, 2003.

BACKGROUND OF THE INVENTION

This is a provisional patent application, filed under 37 C.F.R. 1.53(b)(2).

1. Field of The Invention

Applicant's invention relates to a stable field-deployable reference electrode to facilitate potential measurements such as in corrosion sensing and monitoring.

2. Background Information

Presently, monitoring and measurement of the potential of metals in various environments is used in a broad array of industries, including cathodic protection of structures such as pipelines, storage tanks and bridges. The main limitations associated with reference electrodes are their short in-service life and the need for replacement/replenishment of the reference fluid within the reference cell. Some reference electrodes are used in field applications, the most common being the copper/copper-sulfate reference electrode. Though it can be used to provide a suitable reference point with which to make a measurement, copper sulfate reference electrodes cannot be left in the field over an extended period of time without significant

maintenance. Thus, these reference electrodes need to be positioned in such a way to facilitate access, which is not always optimal with respect to the location where the measurement needs to be taken. Thus, there exists a need to have a more stable, lower maintenance reference electrode. Such an electrode would enable semi-permanent placement for in-field applications without high levels of maintenance.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a novel semi-permanent reference electrode.

Another object of the present invention is to provide a novel semi-permanent reference electrode that incorporates an outer electrode body, cap, porous plug, wire and fill solution that can be utilized in field applications.

Still another object of the present invention is to provide a novel semi-permanent reference electrode that incorporates a fill solution that can be maintained at a field location due to the presence of moisture in the field.

Yet another object of the present invention is to provide a novel semi-permanent reference electrode wherein the fill solution is a saturated salt solution.

It is another object of the present invention to provide a novel semi-permanent reference electrode wherein the solid salt used to form the fill solution is both

hygroscopic and has a low deliquescence point.

An additional object of the present invention is to provide a novel semi-permanent reference electrode wherein the fill solution has a constant pH.

It is still another object of the present invention to provide a novel semi-permanent reference electrode wherein the cap has an opening passing from the external environment to the internal environment of the outer electrode body to allow moisture into the outer electrode body to combine with the solid salt to maintain the fill solution.

Yet an additional object of the present invention is to provide a novel semi-permanent reference electrode with the wire having the ability to maintain a relatively stable reference point in various field environments as well as in the saturated salt solution.

It is another object of the present invention to provide a novel semi-permanent reference electrode wherein the solid salt of the fill solution is hydrolyzable.

In satisfaction of these and related objectives, Applicant's present invention provides a semi-permanent reference electrode for use in monitoring and measuring metals in field applications, such as cathodic protection. This electrode has an outer electrode body with a cap and porous plug. The outer electrode body is filled with a fill solution which is a saturated salt solution formed from a solid salt that is hygroscopic with a low deliquescence point. When the fill solution dries out, it draws moisture from

the environment to maintain the solution. An opening is provided in the cap to allow moisture into the outer electrode body to maintain the solution. This fill solution must maintain a constant pH for use in the reference electrode. A wire is used within the outer electrode body which connects to a voltmeter. This voltmeter measures the potential difference between the reference electrode and the field component of interest, which can include pipelines, storage tanks and bridges.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of the preferred embodiment of the present invention as it would exist in a field application.

Fig. 2 is a cross section of the preferred embodiment of the present invention.

Fig. 3 is an exploded view of the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1, a perspective view of the preferred embodiment of the present semi-permanent reference electrode 100 as it would exist in a field application is shown. Semi- permanent reference electrode 100, with constant potential, is used in measuring the potential of the working electrode, which is where electrochemical reactions being studied occur. The semi-permanent reference electrode 100 and the working electrode

together make up a cell. In corrosion testing the working electrode can be the metal itself, which for purposes of Fig. 1 will be the pipe 101. Semi-permanent reference electrode 100 allows for repeatability in the potential measurement.

The present semi-permanent reference electrode 100 can be used for determining the rate of corrosion or the extent of cathodic protection of a metallic object, such as the pipe 101, in a system that utilizes a voltmeter 102. Semi-permanent reference electrode 100 is placed on the earth's surface directly above the pipe 101. Semi-permanent reference electrode 100 is connected to the positive terminal of a voltmeter 102, the negative terminal of the voltmeter 102 being connected to pipe 101. Voltmeter 102 measures the potential difference between the pipe 101 and the semi-permanent reference electrode 100 to determine the corrosion potential.

To determine the extent of cathodic protection of pipe 101, direct current flow is produced onto pipe 101 for cathodic protection. This cathodic protection reduces the rate of corrosion by shifting the corrosion potential of the pipe 101, or other metallic object under investigation, toward a less oxidizing potential. In other words, the current flow through the environment forces pipe 101 to assume a negative electrical polarity with regard to the environment.

For cathodic protection, semi-permanent reference electrode 100 is placed on the earth's surface directly above the pipe 101. Semi-permanent reference electrode 100 is

connected to the positive terminal of a voltmeter 102, the negative terminal of the voltmeter 102 being connected to pipe 101. Voltmeter 102 measures the potential difference between the pipe 101 and the semi-permanent reference electrode 100 to determine whether full cathodic protection has been obtained. Potentials on pipe 101 which are less negative indicate less than full cathodic protection while potentials which are more negative indicate more cathodic protection or wasted energy. The results of the potential measurement for rates of corrosion or the extent of cathodic protection can be recorded with a computer 103. An external power supply 104 is provided to supply a potential to the pipe 101 if necessary.

For purposes of the present invention, a counter electrode (not shown) may be utilized. The role of the counter electrode is to receive a majority of the current, rather than the current flowing directly from the working electrode, or pipe 101, to the semi-permanent reference electrode 100, so that only a small amount of the current flows from the pipe 101 to the semi-permanent reference electrode 100. This would alleviate concerns about high currents possibly flowing through the semi-permanent reference electrode 100 and possibly damaging it.

Fig. 2 is a cross section view of the preferred embodiment of the semi-permanent reference electrode 100. Semi-permanent reference electrode 100 is composed of an outer electrode body 105 which is generally cylindrical having openings at both ends,

one end being sealed with a cap 109 and the other end sealed with a porous plug 106. Outer electrode body 105 is formed from any inert material that resists corrosion, such as but not limited to, glass, Teflon, polycarbonate, and polypropylene. Non-breakable materials are preferred for field application. Cap 109 can be of any inert material, such as but not limited to, Teflon and rubber.

Porous plug 106 is provided to maintain the internal environment of semi-permanent reference electrode 100 and to minimize either contamination of the semi-permanent reference electrode 100 by the environment or the environment by the semi-permanent reference electrode 100, while still allowing the passage of electrons. Porous plug 106 can be a porous frit or other membrane standard in the industry, such as, but not limited to, porous zirconia and porous alumina.

Fill solution 107 is contained within outer electrode body 105. The fill solution 107 of the present semi-permanent reference electrode 100 is formed from a solid salt and is maintained in solution in the field by way of moisture from the environment. The solid salt of fill solution 107 has two key properties. First, the solid salt used to form fill solution 107 is hygroscopic, that is, an essential property of the solid salt of the fill solution 107 is that it be able to take up water from the surrounding atmosphere. Further to this hygroscopic characteristic, the solid salt of the fill solution 107 must have a low deliquescence point, that is, the relative humidity at which the solid salt of the fill

solution 107 takes up water and is in equilibrium with fill solution 107 should be relatively small to allow maintenance of the fill solution 107 as a saturated salt solution and operation of the semi-permanent reference electrode 100 in various field environments.

The fill solution 107 must also have a constant pH since the measured potential is pH dependent. Therefore, the second key characteristic of the solid salt of the fill solution 107 is that it be hydrolyzable, that is, capable of undergoing hydrolysis or chemical reaction with water. The solid salt which forms the fill solution 107 of the present invention can include, but is not limited to, salts of magnesium, calcium, zinc and iron such as magnesium chloride or sodium magnesium acetate.

An opening 110 is provided through cap 109 to allow moisture from the external environmental to penetrate into the fill solution 107 for maintenance of the solution. Wire 108 penetrates cap 109 with one end situated in the fill solution 107 and the other end connected to voltmeter 102 (See Fig. 1). Due to the nature of fill solution 107 and the field environment, wire 108 must maintain a relatively stable reference point in a wide array of environments and must not corrode at a high rate. Wire 108 includes, but is not limited to, oxidized tungsten and oxidized iridium.

In Fig. 3 an exploded view of the present semi-permanent reference electrode 100 is shown having an outer electrode body 105 which is generally cylindrical having

openings at both ends, one end having a cap 109 and the other end continuous into a funnel section 111 and having a porous plug 106. Cap 109 preferably threads within one end opening of outer electrode body 105; however, other types of caps may be used that do not utilize threads.

Although the invention has been described with reference to specific embodiments, this description is not meant to be construed in a limited sense. Various modifications of the disclosed embodiments, as well as alternative embodiments of the inventions will become apparent to persons skilled in the art upon the reference to the description of the invention. It is, therefore, contemplated that the appended claims will cover such modifications that fall within the scope of the invention.